

**DETAILED FOUNDATION INVESTIGATION AND DESIGN REPORT
FOR VERMILION RIVER BRIDGE REPLACEMENT
HIGHWAY 144, SITE 46-50
WP 158-95-00
TOWNSHIPS OF DOWLING AND BALFOUR
DISTRICT 54, SUDBURY**

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- 3 cc: Stantec Consulting Ltd. for distribution to Ministry of Transportation
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PML Ref.: 02TF060A
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Geocres No.: 41I-158

February 2004

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DETAILED FOUNDATION INVESTIGATION REPORT

for
Vermilion River Bridge Replacement
Highway 144, Site 46-50
WP 158-95-00
Townships of Dowling and Balfour
District 54, Sudbury

INTRODUCTION

This report summarizes the results of the detailed foundation investigation carried out in connection with the proposed replacement of the Vermilion River Bridge located on Highway 144 west of Sudbury, Ontario. The investigation was conducted for Stantec Consulting Ltd. (Stantec) on behalf of the Ministry of Transportation of Ontario.

The site is located on Highway 144 at the Vermilion River crossing, about 8 km west of Chelmsford, in the Town of Rayside-Balfour (Geographic Township of Balfour) and Town of Onaping Falls (Geographic Township of Dowling), within the Regional Municipality of Sudbury, Ontario.

The project limits extend between approximate Station 20+330 (Township of Balfour) and Station 10+005 (Township of Dowling). There is one chainage equation within the project limits:

$$10+000.000 \text{ Township of Dowling} = 20+435.622 \text{ Township of Balfour}$$

The report pertains to the proposed bridge replacement and approaches within about 20 m of the abutments.

SITE DESCRIPTION

Highway 144 is designated as a north-south road. Therefore, the bridge alignment is also considered to be north-south even though the highway is actually oriented in the northwest-southeast direction at the bridge location.

The existing bridge structure is located in an area where bedrock is exposed or mantled with a thin soil cover.

The surrounding area is relatively flat, with local relief of 7 to 8 m near the river crossing. Lands to the east and west are generally undeveloped and bush covered while a number of single family residences are situated on properties along the highway to the north and south. A concrete abutment along with the approach fill for a former bridge structure is located about 30 m upstream of the present bridge, on the east side of the river.

The Vermilion River flows from southeast to northwest at the site. In general, the river in the vicinity of the bridge is about 50 m wide. However, it narrows considerably just upstream of the bridge, dividing into two channels that are approximately 5 m and 15 m wide, separated at the bridge location by a 6 to 12 m wide island, and passing over a set of rapids at/just downstream of the bridge site before widening out again. The water level in the river drops some 2 m over the length of the rapids and was about 7 to 9 m below the bridge deck at the time of our site visits in December, 2002 and April, 2003.

The existing bridge comprises a two span steel plate girder superstructure with a total length of about 40 m. Both abutments and the centre pier are supported on spread footings founded on the exposed bedrock. The centre pier is founded on the rock island in the middle of the river.

INVESTIGATION PROCEDURES

The field work for this study was carried out in three stages.

The first stage involved a preliminary investigation performed on December 17, 2002 before the design alignment of the replacement bridge was established. This study consisted of a survey to establish the elevation of the soil/bedrock outcrops at strategic locations in the vicinity of the existing bridge and visual examination of geologic features exposed at the bedrock surface. Other than some very limited manual probing along the edge of the bedrock exposure, the investigation was non-intrusive.

The survey involved locating 56 test points (numbered in the 100 series), establishing the ground surface elevation at each accessible point and describing the exposed bedrock or soil cover conditions at each point. The factual data from the preliminary investigation is reproduced in Appendix A.

Relevant test points (denoted "Auger Probes") from the preliminary investigation are shown on Drawing 1.

The second stage was carried out during the period of September 8 to 10, 2003 after the alignment of the replacement bridge was established. This phase of the study involved 20 boreholes (numbered in the 1000 series from 1001 to 1020) advanced to depths up to 5.4 m, including some 3 m of rock coring in six boreholes, as detailed in Table I.

The third stage was conducted during the period of October 15 to 28, 2003 following a design change to the configuration of the bridge and the location of the proposed bridge abutments and centre pier. Twenty-two boreholes (numbered 1021 to 1042) were advanced to depths up to 6.5 m, including 3.0 to 3.6 m of rock coring in two boreholes (see Table I), during this phase of the work.

The locations of and ground surface elevations at the boreholes and auger probes were established in the field by Peto MacCallum Ltd. and are shown on Drawing 1. The following temporary benchmark (TBM), indicated on the general arrangement drawing of the existing bridge dated May, 1958, was used for vertical reference:

TBM: Top of existing bridge deck
 Centreline of pavement at middle expansion joint
 Elevation: 267.553 (geodetic, metric)

The boreholes were advanced using portable hand augers and portable HILTI-250 core equipment as well as continuous flight solid stem augers (supplemented by NW casing techniques), powered by track-mounted CME-55 and mobile B-57 drill rigs, supplied and operated by a specialist drilling contractor, working under the full-time supervision of a member of our engineering staff.

Whenever possible, representative samples of the soil were recovered at frequent depth intervals using a conventional split spoon sampler during drilling. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata. The groundwater conditions in the boreholes were closely monitored in the course of the field work.

All of the recovered samples were returned to our laboratory for detailed visual examination, classification and routine moisture content determinations. In addition, three grain size distribution analyses were carried out on selected soil samples; the results are presented in Figures 1 and 2, appended.

A photographic record was made to illustrate the general conditions and pertinent features at the site. Representative photos are included in Plates 1 to 14 (Appendix A). The remaining photos will be kept on file for future reference.

GEOLOGY

This area is located within the Sudbury Basin which forms part of a complex geologic area known as the Sudbury Structure, formed as the result of a large meteorite impact about 1.85 billion years ago. The Sudbury Basin is occupied by rocks of the Whitewater Group. The Chelmsford Formation, representing the uppermost formation of the Whitewater Group is described as a succession of lithic wackes, siltstones and carbonaceous mudstones.

SUMMARIZED SITE CONDITIONS

Reference is made to the appended Record of Borehole sheets for details of the subsurface conditions including soil classifications, inferred stratigraphy, boundary elevations, standard penetration test resistance values, groundwater observations as well as the results of laboratory moisture content determinations and grain size distribution analyses.

The test hole locations and stratigraphic cross-sections prepared from the borehole data are presented on Drawings 1 and 2 respectively. In addition, selected photographs of the site are presented in Plates 1 to 14 (Appendix B).

In general, the river has cut down to and exposed the bedrock surface in the vicinity of the site and it is apparent that the river channel(s) are controlled by the structural features of the bedrock.

The subsurface stratigraphy revealed in the boreholes drilled at the site generally comprised exposed bedrock or a surficial topsoil/fill underlain by sandy/silty deposits mantling shallow bedrock. Except for borehole 1040 terminated on a boulder, bedrock was contacted in all boreholes at depths of 0.0 to 5.3 m (elevation 260.1 to 266.1). The strata encountered are summarized below.

Topsoil

Topsoil was encountered surficially in boreholes 1022 and 1026, drilled at the south abutment as well as 1032 to 1039 drilled at the north abutment. It was 200 to 600 mm thick, contained occasional cobbles/boulders, and was penetrated at elevation 262.7 to 266.3.

Fill

Rockfill was identified at the north abutment and approach to the proposed replacement bridge in boreholes 1014 to 1017, 1019 and 1020. This unit was 0.6 to 2.3 m thick and loose to compact in relative density. The rockfill was penetrated at elevation 260.9 to 266.1.

Fill consisting of sand and gravel with cobbles and boulders and/or silty sand/sand was encountered at the south abutment and approach to the replacement bridge in boreholes 1021, 1024, 1040 and 1041. This unit was 0.9 to 2.8 m thick and penetrated at elevation 263.1 to 265.0.

Sand

Sand was encountered surficially in boreholes 1001, 1003, 1023, 1025, 1027 and below the topsoil/fill at depths of 0.2 to 1.2 m (elevation 262.7 to 266.3) in boreholes 1022 and 1024, located at the south approach/abutment as well as boreholes 1019, 1026 and 1032 to 1039 at the north approach/abutment. In borehole 1021, it was described as silty sand till and revealed at 2.8 m depth (elevation 263.5). The sandy deposit was very loose to compact (SPT-'N' values of 4 to 27) and had a thickness of 0.3 to 2.5 m. The moisture content of the deposit varied between 6 and 18%.

The results of two grain size distribution analyses conducted on representative samples of the deposit are presented in Figure 1. The sand was penetrated at depths of 0.3 to 5.3 m (elevation 261.0 to 265.7).

Silt/Clayey Silt

A layer of silt was identified below the sand at depths of 0.6 and 2.2 m (elevation 262.0 and 263.8) on the west side of the south abutment of the replacement bridge in boreholes 1022 and 1024. This unit was loose to compact (SPT-'N' values of 9 to 22) and 1.0 and 1.6 m thick. The moisture content of the silt ranged from 19 to 26%. The unit was penetrated at depths of 2.2 to 3.2 m (elevations 261.0 and 262.2). The results of a grain size distribution analysis conducted on a representative sample of the silt are presented in Figure 2.

A 900 mm thick layer of clayey silt was encountered directly beneath the silt at 2.2 m depth (elevation 262.2) in borehole 1022. This unit was stiff in consistency and had a moisture content of about 28%.

Cobbles/Boulders

A deposit of cobbles/boulders was encountered at depths of 1.4 to 3.2 m (elevation 261.0 to 264.3) in boreholes 1024, 1025 (south abutment) and 1032 to 1036 (north abutment). The thickness of the deposit was 200 to 300 mm.

Bedrock

Bedrock was exposed in boreholes 1002, 1004 to 1007, and 1042 at the south abutment, 1008 to 1013 and 1028 to 1031 at the centre pier as well as 1018 at the north abutment at elevation 260.1 to 262.9. Bedrock was also contacted below the fill or native soils at depths of 0.3 to 5.3 m (elevation 260.9 to 266.1) in the remaining boreholes, except borehole 1040 terminated on boulder.

The bedrock comprises a grey to dark grey metasedimentary rock belonging to the Chelmsford Formation. The material is very fine grained, high strength and unweathered. A detailed description of the bedrock is provided in Table II.

The measured core recovery was 100% except in the upper 500 mm of the first run in borehole 1014 where it was 97%. The RQD determined from rock cores typically ranged from 80 to 100% (RQD of 70 and 75% measured in core from separate holes) indicating a good to excellent quality rock. With the exception of borehole 1005, there was complete return of drill water during coring. Complete loss of circulation was experienced in borehole 1005 at 0.7 m (elevation 260.5) due to a 25 mm void in the rock.

The rock mass exhibits a number of intersecting discontinuities that have combined to form a rugged or jagged appearance in some areas, and relatively large flat faces in adjacent areas.

The primary system is very distinct, striking at 58 to 61° and dipping down to the north (true north) at 40 to 50°. It is exposed in the relatively steep rock face that forms the south bank of the river east (upstream) of the existing bridge. This system controls the structure of the rock and, as a consequence, the alignment of the river channel at the site. Joint spacing ranges from about 200 mm up to 1 m and may be classified as close to moderate. The joints are generally tight or locally oxidized. The face is typically smooth planar.

Secondary cross jointing is evident, although more poorly defined than the primary system. It is typically almost perpendicular to the main system. Spacing is close to moderate. Joints are tight to oxidized and the face is typically smooth planar.

There is also evidence of an additional more poorly defined system(s) that cuts across the first two at varying angles.

Groundwater

Groundwater was not observed in any of the boreholes during or upon completion of drilling. There was also no evidence of groundwater seepage along the banks of the river within the exposed areas. However, minor seepage should be anticipated locally at the soil/bedrock contact, within depressions in the bedrock surface and in association with discontinuities in the bedrock close to/below the level of the adjacent river.

The water level in the Vermilion River drops some 2 m within the site limits and was approximately at elevation 258.6 to 260.7 at the time of our site visit on December 17, 2002. In April 2003, the water level in the south and north channels of the river separated at the bridge location by the rock island was at respective elevations 259.6 and 261.4 as indicated on Drawing P2 prepared by Stantec Consulting Ltd. (00458V01.dwg received in an e-mail dated September 30, 2003).

Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

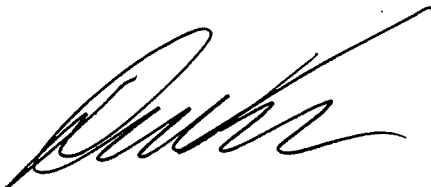
CLOSURE

The first stage of the field work was carried out under the supervision of Mr. J.F. Wright, B.Sc., Senior Geologist, and direction of Mr. C.M.P. Nascimento, P.Eng., Senior Foundations Engineer. The second and third stages of the field work were carried out under the supervision of Mr. M. Rapsey and Mr. F. Portela, Senior Technologists, and direction of Mr. C.M.P. Nascimento, P.Eng. The report was prepared by Messrs. Wright, Nascimento, and G.O. Degil, Ph.D., P.Eng., Senior Geotechnical Engineer, and reviewed by Mr. D.W. Kerr, M.Eng., P.Eng., Chief Foundation Engineer. Mr. B.R. Gray, M.Eng, P.Eng., conducted an independent review of the report.

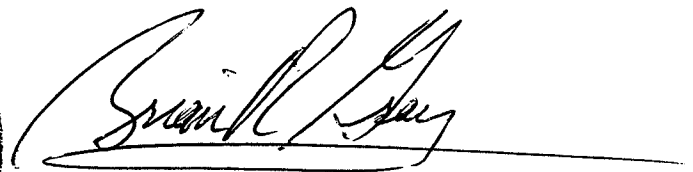
Yours very truly

Peto MacCallum Ltd.




Dennis W. Kerr, M.Eng., P.Eng.
Chief Foundation Engineer




Brian R. Gray, M.Eng., P.Eng.
MTO Designated Contact

GD:mi/lad

TABLE I

**DEPTH OF INVESTIGATION AT BOREHOLE LOCATIONS
VERMILION RIVER BRIDGE, HIGHWAY 144, SITE 46-50
2.2 KM SOUTH OF DOWLING, DISTRICT 54, SUDBURY
G.W.P. 158-95-00**

Borehole No.	Depth (m)		
	Auger	Rock Core ⁽¹⁾	Total
1001	0.9	-	0.9
1002	0.0	3.1	3.1
1003	0.3	-	0.3
1004	0.0	-	0.0
1005	0.0	3.1	3.1
1006	0.0	-	0.0
1007	0.0	-	0.0
1008	0.0	-	0.0
1009	0.0	3.1	3.1
1010	0.0	2.9	2.9
1011	0.0	-	0.0
1012	0.0	-	0.0
1013	0.0	-	0.0
1014	2.3	3.1	5.4
1015	0.9	-	0.9
1016	2.0	-	2.0
1017	1.4	2.9	4.3
1018	0.0	-	0.0
1019	2.3	-	2.3
1020	0.6	-	0.6
1021	5.3	-	5.3
1022	3.1	-	3.1
1023	1.7	-	1.7
1024	3.5	3.0	6.5
1025	1.6	-	1.6
1026	1.2	-	1.2
1027	1.9	-	1.9
1028	0.0	-	0.0
1029	0.0	-	0.0
1030	0.0	-	0.0
1031	0.0	-	0.0
1032	2.0	-	2.0
1033	2.1	-	2.1
1034	1.7	-	1.7
1035	2.0	-	2.0
1036	2.0	-	2.0
1037	2.1	3.6	5.7
1038	0.9	-	0.9
1039	0.9	-	0.9
1040	1.7	-	1.7
1041	0.9	-	0.9
1042	0.0	-	0.0

(1) NQ diamond rock coring equipment.

TABLE II

ROCK CORE DESCRIPTION
VERMILION RIVER BRIDGE, HIGHWAY 144, SITE 46-50
2.2 KM SOUTH OF DOWLING, DISTRICT 54, SUDBURY
G.W.P. 158-95-00

CORE RECOVERY					CORE DESCRIPTION	
BH	RC	DEPTH (m)	Rec (%)	RQD (%)	DEPTH (m)	DESCRIPTION
1002	1	0.0 – 1.1	100	100	0.0 – 3.1	METASEDIMENTARY: Grey to dark grey, very fine grained, high strength, unweathered, close to moderate spaced flat to dipping joints, smooth to rough planar, oxidized to tight, excellent quality. (Chelmsford Formation)
	2	1.1 – 1.7	100	100		
	3	1.7 – 3.1	100	100		
1005	1	0.0 – 0.7	100	100	0.0 – 3.1	METASEDIMENTARY: Grey to dark grey, very fine grained, high strength, unweathered, close spaced flat to dipping joints, smooth to rough planar, oxidized to tight, with occ. white encrustation on partings, good to excellent quality. (Chelmsford Formation); 25 mm void at 0.7 m.
	2	0.7 – 1.7	100	86		
	3	1.7 – 3.1	100	91		
1009	1	0.0 – 1.3	100	90	0.0 – 3.1	METASEDIMENTARY: Grey to dark grey, very fine grained, high strength, unweathered, close to moderate spaced flat to dipping joints, smooth to rough planar, oxidized to tight, with occ. white encrustation or brown oxidation on partings, fair to excellent quality. (Chelmsford Formation)
	2	1.3 – 2.6	100	70		
	3	2.6 – 3.1	100	100		
1010	1	0.0 – 0.8	100	82	0.0 – 2.9	METASEDIMENTARY: Grey to dark grey, very fine grained, high strength, unweathered, close to moderate spaced dipping joints, smooth to rough planar, tight, good to excellent quality. (Chelmsford Formation)
	2	0.8 – 1.7	100	100		
	3	1.7 – 2.3	100	100		
	4	2.3 – 2.9	100	75		
1014	1	2.3 – 3.8	97	97	2.3 – 5.4	METASEDIMENTARY: Grey to dark grey, very fine grained, high strength, unweathered, close to moderate spaced dipping joints, smooth to rough planar, oxidized to tight, excellent quality. (Chelmsford Formation)
	2	3.8 – 5.4	100	98		

TABLE II

ROCK CORE DESCRIPTION
VERMILION RIVER BRIDGE, HIGHWAY 144, SITE 46-50
2.2 KM SOUTH OF DOWLING, DISTRICT 54, SUDBURY
G.W.P. 158-95-00

CORE RECOVERY					CORE DESCRIPTION	
BH	RC	DEPTH (m)	Rec (%)	RQD (%)	DEPTH (m)	DESCRIPTION
1017	1	1.4 – 2.8	100	100	1.4 – 4.3	METASEDIMENTARY: Grey to dark grey, very fine grained, high strength, unweathered, moderate spaced dipping joints, smooth to rough planar, tight, excellent quality. (Chelmsford Formation)
	2	2.8 – 4.3	100	100		
1024	5	3.5 – 5.0	100	90	3.5 – 6.5	METASEDIMENTARY: Dark grey with light grey layers below 5.0 m depth, very fine grained, high strength, unweathered, close to moderate spaced dipping joints, smooth to rough planar, tight to oxidized, excellent quality. (Chelmsford Formation).
	6	5.0 – 6.5	100	100		
1037	4	2.6 – 4.1	100	80	2.6 – 5.7	METASEDIMENTARY: Dark grey with light grey layers below 4.5 m depth, very fine grained, high strength, unweathered, two sets of close to moderate spaced dipping joints, smooth to rough planar, tight to oxidized, with numerous chalcopryrite inclusions in upper few cm, good to excellent quality. (Chelmsford Formation).
	5	4.1 – 5.7	100	100		

RQD = Rock Quality Designation

Originated: _____ FP
Compiled: _____ JW
Checked: _____ CN

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 31mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (31mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND /OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	< 50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S SPLIT SPOON	T P THINWALL PISTON
W S WASH SAMPLE	O S OSTERBERG SAMPLE
S T SLOTTED TUBE SAMPLE	R C ROCK CORE
B S BLOCK SAMPLE	P H T W ADVANCED HYDRAULICALLY
C S CHUNK SAMPLE	P M T W ADVANCED MANUALLY
T W THINWALL OPEN	F S FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
C_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_f	kPa	REMOULDED SHEAR STRENGTH
S_f	1	SENSITIVITY = $\frac{c_u}{\tau_f}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ³ /s	RATE OF DISCHARGE
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w - w_p}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kV/m ²	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

RECORD OF BOREHOLE No 1001

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 804 N; 281 364 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE PORTABLE HAND AUGER COMPILED BY G.D.
DATUM Geodetic DATE September 10, 2003 CHECKED BY C.N.


SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
264.7	Ground Surface					*		20	40	60	80	100					
0.0	Sand, trace silt trace gravel	•••															
	Brown Moist	•••															
263.8	(no sample taken)	•••					264										
0.9	End of borehole																
	Refusal on probable bedrock																
	* Borehole dry on completion of drilling																

RECORD OF BOREHOLE No 1002

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 807 N; 281 342 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE HILTI 250 COMPILED BY G.D.
DATUM Geodetic DATE September 10, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100									
								SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE									
							20 40 60 80 100					WATER CONTENT (%) 20 40 60					
261.3	Ground Surface																
0.0	Bedrock, Metasedimentary Refer to Table II for bedrock description		1	RC NQ	REC 100%		261										RQD 100%
			2	RC NQ	REC 100%		260										RQD 100%
			3	RC NQ	REC 100%		259										
258.2	End of borehole																
3.1	* Borehole charged with drilling water																

RECORD OF BOREHOLE No 1003

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 810 N; 281 353 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE PORTABLE HAND AUGER COMPILED BY G.D.
DATUM Geodetic DATE September 10, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
262.6	Ground Surface	••				*		20	40	60	80	100					GR SA SI CL
0.0	Sand, trace silt trace gravel	••															
0.3	Brown Moist (no sample taken) End of borehole Refusal on probable bedrock						262										
	* Borehole dry on completion of drilling																

RECORD OF BOREHOLE No 1004

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 808 N; 281 339 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE HILTI 250 COMPILED BY G.D.
DATUM Geodetic DATE September 10, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT			LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					W _p — W — W _L WATER CONTENT (%)					
260.3	Ground Surface						20	40	60	80	100	20	40	60				
0.0	Bedrock at surface					*	260											
	* Borehole dry on completion of drilling																	

RECORD OF BOREHOLE No 1005

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 811 N; 281 350 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE HILTI 250 COMPILED BY G.D.
DATUM Geodetic DATE September 10, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					

1 of 1

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METRIC

Foundation Design

G.W.P. <u>158 - 95 - 00</u>	LOCATION <u>Co-ords. 5 160 810 N; 281 344 E.</u>	ORIGINATED BY <u>F.P.</u>
DIST <u>54</u> HWY <u>144</u>	BOREHOLE TYPE <u>HILTI 250</u>	COMPILED BY <u>G.D.</u>
DATUM <u>Geodetic</u>	DATE <u>September 10, 2003</u>	CHECKED BY <u>C.N.</u>

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+7, X⁵: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 1008

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 814 N; 281 327 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE HILTI 250 COMPILED BY G.D.
DATUM Geodetic DATE September 10, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
260.3	Ground Surface						20	40	60	80	100						
0.0	Bedrock at surface						260										
	* Borehole dry on completion of drilling																

RECORD OF BOREHOLE No 1009

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 819 N; 281 332 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE HILTI 250 COMPILED BY G.D.
DATUM Geodetic DATE September 09, 2003 CHECKED BY C.N.


SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
260.1	Ground Surface																
0.0	Bedrock, Metasedimentary Refer to Table II for bedrock description		1	RC NQ	REC 100%		260										RQD 90%
			2	RC NQ	REC 100%		259										RQD 70%
			3	RC NQ	REC 100%		258										RQD 100%
257.0	End of borehole						257										
3.1	* Borehole charged with drilling water																

RECORD OF BOREHOLE No 1010

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 817 N; 281 324 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE HILTI 250 COMPILED BY G.D.
DATUM Geodetic DATE September 09, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE												
261.4	Ground Surface							20	40	60	80	100								
0.0	Bedrock, Metasedimentary Refer to Table II for bedrock description		1	RC NQ	REC 100%		261										RQD 82%			
			2	RC NQ	REC 100%		260											RQD 100%		
			3	RC NQ	REC 100%													RQD 100%		
			4	RC NQ	REC 100%		259											RQD 75%		
258.5	End of borehole																			
2.9																				
	* Borehole charged with drilling water																			

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 820 N; 281 331 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE HILTI 250 COMPILED BY G.D.
DATUM Geodetic DATE September 10, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20	40	60	80	100	○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL		
261.9	Ground Surface																
0.0	Bedrock at surface						261										
* Borehole dry on completion of drilling																	

RECORD OF BOREHOLE No 1012

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 816 N; 281 331 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE HILTI 250 COMPILED BY G.D.
DATUM Geodetic DATE September 10, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED	● QUICK TRIAXIAL	+	×	FIELD VANE						LAB VANE	20	40
261.0	Ground Surface					*										GR SA SI CL				
0.0	Bedrock at surface																			
	* Borehole dry on completion of drilling																			

RECORD OF BOREHOLE No 1014

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 829 N; 281 296 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE CFHSA + NW CASING COMPILED BY G.D.
DATUM Geodetic DATE September 08, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE															
263.2	Ground Surface					*	20	40	60	80	100					GR	SA	SI	CL				
0.0	Rockfill (Boulders and cobbles) (no sample taken)																						
260.9	Bedrock, Metasedimentary Refer to Table II for bedrock description		1	RC NQ	REC 97%		263																
2.3							262																
							261																
							260																RQD 97%
			2	RC NQ	REC 100%		259																
							258														RQD 98%		
257.9	End of borehole																						
5.4	* Borehole charged with drilling water																						

RECORD OF BOREHOLE No 1015

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 832 N; 281 307 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE September 08, 2003 CHECKED BY C.N.


SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
263.4	Ground Surface					*		20	40	60	80	100					GR SA SI CL
0.0	Rockfill with sandy silt topsoil Dark Brown (no sample taken)						263										
262.5	End of borehole																
0.9	Refusal on probable bedrock																
	* Borehole dry on completion of drilling																

RECORD OF BOREHOLE No 1016

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 830 N; 281 294 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE September 08, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
265.8 0.0	Ground Surface Rockfill with sandy silt topsoil Dark Brown (no sample taken)																
263.8 2.0	End of borehole Refusal on probable bedrock * Borehole dry on completion of drilling																

1 of 1

METRIC

Foundation Design

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1 of 1

METRIC

Foundation Design

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100		W _p	W	W _L		
								SHEAR STRENGTH kPa						
262.9	Ground Surface							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%)					
								20 40 60 80 100	20	40	60		GR SA SI C	





* Borehole dry on completion of drilling

RECORD OF BOREHOLE No 1019

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 831 N; 281 300 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE September 08, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
265.8	Ground Surface							20	40	60	80	100					
0.0	Rockfill with sandy silt topsoil		1	SS	6		265										Augers grinding from 0.2 m down
264.6	Loose to Dark Moist compact brown		2	SS	12												
1.2	Sand, some gravel some silt trace clay		3	SS	13		264										12 72 13 3
263.5	Compact Brown Moist																
2.3	End of borehole																
	Refusal on probable bedrock																
	* Borehole dry on completion of drilling																

RECORD OF BOREHOLE No 1020

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 839 N; 281 282 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE September 08, 2003 CHECKED BY C.N.

SOIL PROFILE		SAMPLES				GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
266.7	Ground Surface																
0.0	Rockfill with sandy silt topsoil	X															
266.1	Dark brown	X															
0.6	(no sample taken) End of borehole Refusal on probable bedrock																
	* Borehole dry on completion of drilling																

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+ X⁵ : Numbers refer to
Sensitivity

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RECORD OF BOREHOLE No 1021

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 798 N; 281 370 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE October 28, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
266.3	Ground Surface						20	40	60	80	100						
0.0	Sand and gravel with cobbles and boulders Brown (FILL)						266										
							265										
264.3							264										
2.0	Silty sand with gravel and cobble inclusions Brown (FILL)						263										
263.5							262										
2.8	Silty sand till trace gravel trace clay Brown Wet some gravel some cobbles						261										
261.0	End of borehole Refusal on probable bedrock																
5.3																	
	* Borehole dry on completion of augering																

RECORD OF BOREHOLE No 1022

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 798 N; 281 354 E. ORIGINATED BY M.R.
DIST 54 HWY 144 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE October 15, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kn/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
264.4	Ground Surface							20	40	60	80	100								
0.0	Topsoil																			
0.2	Dark brown																			
263.8	Sand, with silt																			
0.6	Rusty Dry																			
	Silt, some sand trace clay		1	SS	9															
	Loose to Light Wet compact brown		2	SS	15															
262.2	Clayey silt, trace sand with thin layers of silty clay		3	SS	11															
2.2	Stiff Brown																			
261.4	End of borehole																			
3.1	Refusal on probable bedrock																			
	* Borehole dry on completion of drilling																			

RECORD OF BOREHOLE No 1023

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 810 N; 281 356 E. ORIGINATED BY M.R.
DIST 54 HWY 144 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE October 15, 2003 CHECKED BY C.N.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
263.9	Ground Surface						20	40	60	80	100					
0.0	Silty sand, fine to medium	•														
263.3	Brown Moist	•														
0.6	Sand, fine with silt	•														
	Rusty Moist brown	•														
262.2		•														
1.7	End of borehole															
	Refusal on probable bedrock															
	* Borehole dry on completion of drilling															

RECORD OF BOREHOLE No 1024

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 801 N; 281 352 E. ORIGINATED BY M.R.
DIST 54 HWY 144 BOREHOLE TYPE CFHSA + NW CASING COMPILED BY G.D.
DATUM Geodetic DATE October 15, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT - W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20 40 60 80 100									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE									
264.2	Ground Surface																
0.0	Sand, fine grained with topsoil inclusions Loose Brown Damp		1	SS	6		264										
263.1	(FILL) Sand, fine grained some silt Compact Brown Dry to damp						263										
1.1																	
262.0			2	SS	18		262										
2.2	Silt, some clay trace sand Compact Brown Damp		3	SS	22		261										
261.0			4	SS	50/0.12		260										
3.2	Cobbles/ broken bedrock						259										
260.7	Bedrock, Metasedimentary Refer to Table II for bedrock description		5	RC NQ	REC 100%		258										
3.5			6	RC NQ	RCE 100%												
257.7	End of borehole																
6.5	* Borehole charged with drilling water																

RECORD OF BOREHOLE No 1025

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 807 N; 281 351 E. ORIGINATED BY M.R.
DIST 54 HWY 144 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE October 15, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)						
						20	40	60	80	100	20	40	60				
263.3	Ground Surface																
0.0	Sand, fine grained trace to some silt																
	Rusty brown mottled black																
262.0																	
261.4	Cobbles																
1.6	End of borehole Refusal on probable bedrock																
	* Borehole dry on completion of drilling																

RECORD OF BOREHOLE No 1026

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 803 N; 281 347 E. ORIGINATED BY M.R.
DIST 54 HWY 144 BOREHOLE TYPE HAND AUGERING COMPILED BY G.D.
DATUM Geodetic DATE October 20, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT Y kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
262.9	Ground Surface																
0.0	Topsoil																
0.2	Dark brown Sand, fine with silt																
	Brown Moist to rusty brown						262										
261.7																	
1.2	End of borehole																
	Refusal on probable bedrock																
	* Borehole dry on completion of drilling																

RECORD OF BOREHOLE No 1027

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 808 N; 281 349 E. ORIGINATED BY M.R.
DIST 54 HWY 144 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE October 20, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
263.0	Ground Surface																
0.0	Sand, fine grained trace to some silt Brown Damp	•••••					262										
261.1	End of borehole Refusal on probable bedrock																
1.9																	
	* Borehole dry on completion of drilling																

RECORD OF BOREHOLE No 1028

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 811 N; 281 330 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE HILTI 250 COMPILED BY G.D.
DATUM Geodetic DATE October 28, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
260.5	Ground Surface																
0.0	Bedrock at surface																
	* Borehole dry on completion of drilling																

RECORD OF BOREHOLE No 1029

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 820 N; 281 335 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE HILTI 250 COMPILED BY G.D.
DATUM Geodetic DATE October 28, 2003 CHECKED BY C.N.

SOIL PROFILE		SAMPLES				GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
260.8 0.0	Ground Surface Bedrock at surface							20 40 60 80 100	20 40 60 80 100					GR SA SI CL
	* Borehole dry on completion of drilling													

RECORD OF BOREHOLE No 1030

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 813 N; 281 326 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE HILTI 250 COMPILED BY G.D.
DATUM Geodetic DATE October 28, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
260.5	Ground Surface					*		20	40	60	80	100					GR SA SI CL
0.0	Bedrock at surface																
	* Borehole dry on completion of drilling																

RECORD OF BOREHOLE No 1031

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 822 N; 281 330 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE HILTI 250 COMPILED BY G.D.
DATUM Geodetic DATE October 28, 2003 CHECKED BY C.N.





SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT W	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		20	40	60	80	100					
261.0	Ground Surface															
0.0	Bedrock at surface															
	* Borehole dry on completion of drilling															

RECORD OF BOREHOLE No 1032

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 827 N; 281 296 E. ORIGINATED BY M.R.
DIST 54 HWY 144 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE October 20, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
265.6	Ground Surface					*											
0.0	Topsoil with boulders																
265.0	Dark brown																
0.6	Sand, with silt and cobbles						265										
	Brown Moist																
263.9							264										
1.7	Boulders																
263.6																	
2.0	End of borehole																
	Refusal on probable bedrock																
	* Borehole dry on completion of drilling																

RECORD OF BOREHOLE No 1033

1 of 1

METRIC

Foundation Design

G.W.P. <u>158 - 95 - 00</u>	LOCATION <u>Co-ords. 5 160 836 N; 281 301 E.</u>	ORIGINATED BY <u>M.R.</u>
DIST <u>54</u> HWY <u>144</u>	BOREHOLE TYPE <u>Continuous Flight Solid Stem Augers</u>	COMPILED BY <u>G.D.</u>
DATUM <u>Geodetic</u>	DATE <u>October 20, 2003</u>	CHECKED BY <u>C.N.</u>

[illegible]

RECORD OF BOREHOLE No 1034

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 829 N; 281 292 E. ORIGINATED BY M.R.
DIST 54 HWY 144 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE October 20, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
265.8	Ground Surface					*											
0.0	Topsoil																
0.3	Dark brown Sand, fine with silt Loose Brown Dry		1	AS	-		265										
264.3																	
1.5	Cobbles																
264.1	End of borehole																
1.7	Refusal on probable bedrock																
	* Borehole dry on completion of drilling																

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 831 N; 281 298 E. ORIGINATED BY M.R.
DIST 54 HWY 144 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE October 20, 2003 CHECKED BY C.N.

ON_MOT VER3 02TF060A.GPJ ON_MOT.GDT 10/29/03 4:19:56 PM

20
15 — 5 (%) STRAIN AT FAILURE
10

METRIC[illegible]

1 of 1

METRIC

Foundation Design

[illegible]

RECORD OF BOREHOLE No 1038

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 830 N; 281 285 E. ORIGINATED BY M.R.
DIST 54 HWY 144 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE October 20, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
265.9	Ground Surface																
0.0	Topsoil Dark brown																
0.3	Sand, fine with silt																
265.0	Loose Brown Dry																
0.9	End of borehole						265										
	Refusal on probable bedrock																
	* Borehole dry on completion of drilling																

RECORD OF BOREHOLE No 1039

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 841 N; 281 278 E. ORIGINATED BY M.R.
DIST 54 HWY 144 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE October 20, 2003 CHECKED BY C.N.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		20	40	60	80	100					
266.6	Ground Surface															
0.0	Topsoil															
0.3	Dark brown Sand, fine with silt															
265.7	Loose Brown Dry					266										
0.9	End of borehole Refusal on probable bedrock															
	* Borehole dry on completion of drilling															

RECORD OF BOREHOLE No 1040

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 808 N; 281 367 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE October 28, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS *	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _p	W	W _L		
266.7 0.0	Ground Surface Sand and gravel, with cobbles and boulders Brown (FILL)																
265.0 1.7	End of borehole Refusal on probable boulder * Borehole dry on completion of augering																

RECORD OF BOREHOLE No 1041

1 of 1

METRIC

G.W.P. 158 - 95 - 00 LOCATION Co-ords. 5 160 811 N; 281 361 E. ORIGINATED BY F.P.
DIST 54 HWY 144 BOREHOLE TYPE Continuous Flight Solid Stem Augers COMPILED BY G.D.
DATUM Geodetic DATE October 28, 2003 CHECKED BY C.N.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
265.3	Ground Surface						20	40	60	80	100						
0.0	Sand and gravel with cobbles and boulders	⊗					265										
264.4	Brown	⊗															
	(FILL)	⊗															
0.9	End of borehole																
	Refusal on probable bedrock																

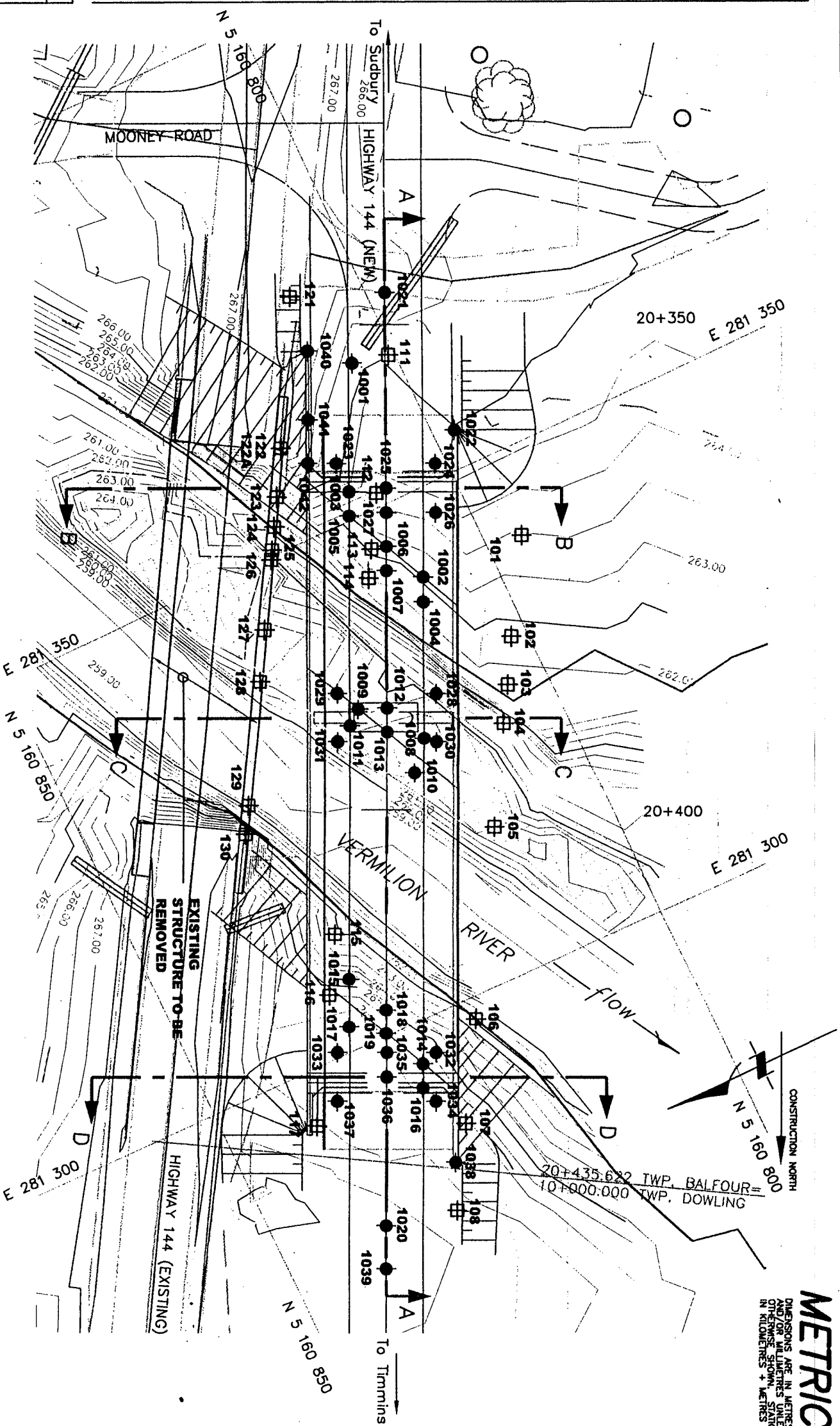
METRIC

20
15 — 5 (%) STRAIN AT FAILURE
10

(Legend Continued)			
BH No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1009	280.1	5 160 819	281 332
1010	281.4	5 160 817	281 324
1011	281.9	5 160 820	281 331
1012	281.0	5 160 816	281 331
1013	281.7	5 160 817	281 329
1014	283.2	5 160 829	281 296
1015	283.4	5 160 832	281 307
1016	284.8	5 160 830	281 294
1017	285.5	5 160 834	281 303
1018	282.9	5 160 830	281 303
1019	285.8	5 160 831	281 300
1020	286.7	5 160 839	281 282
1021	286.3	5 160 798	281 370
1022	284.4	5 160 798	281 354
1023	283.9	5 160 810	281 356
1024	284.2	5 160 801	281 352
1025	283.3	5 160 807	281 351
1026	282.9	5 160 803	281 347
1027	283.0	5 160 806	281 349
1028	280.5	5 160 811	281 330
1029	280.8	5 160 820	281 335
1030	280.5	5 160 813	281 326
1031	281.0	5 160 822	281 330
1032	285.6	5 160 827	281 286
1033	285.5	5 160 836	281 301
1034	285.8	5 160 829	281 292
1035	285.8	5 160 831	281 298
1036	285.8	5 160 833	281 296
1037	285.8	5 160 838	281 296
1038	285.9	5 160 830	281 285
1039	286.6	5 160 841	281 278
1040	286.7	5 160 808	281 367
1041	285.3	5 160 811	281 351
1042	282.4	5 160 813	281 357

AP No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
101	283.3	5 160 796	281 341
102	281.6	5 160 802	281 332
103	259.1	5 160 804	281 328
104	258.6(C)	5 160 808	281 325
105	NOT ACCESSIBLE	5 160 812	281 315
106	NOT ACCESSIBLE	5 160 822	281 298
107	286.1	5 160 827	281 288
108	286.1	5 160 832	281 281
111	284.1	5 160 801	281 364
112	NOT ACCESSIBLE	5 160 808	281 351
113	NOT ACCESSIBLE	5 160 811	281 346
114	NOT ACCESSIBLE	5 160 812	281 344
115	NOT ACCESSIBLE	5 160 831	281 312
116	285.2	5 160 834	281 306
117	286.0	5 160 841	281 295

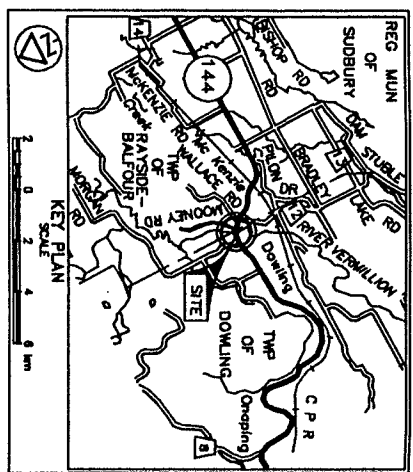
AP No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
121	267.8	5 160 807	281 373
122	283.2	5 160 815	281 360
123	282.5	5 160 817	281 355
124	NOT ACCESSIBLE	5 160 819	281 353
125	NOT ACCESSIBLE	5 160 820	281 351
126	281.5	5 160 821	281 349
127	283.1	5 160 824	281 344
128	280.7	5 160 827	281 339
129	280.7	5 160 833	281 328
130	282.4	5 160 835	281 325



METRIC
DIMENSIONS ARE IN METRES
UNLESS OTHERWISE SHOWN
OTHERWISE SHOWN
IN KILOMETRES + METRES

CONT No	CWP No 158-95-00	
VERMILION RIVER	(Hwy 144, 2.2 km South of Borehole)	
BOREHOLE LOCATIONS		SHEET

PMI **Peto MacCallum Ltd.**
CONSULTING ENGINEERS



LEGEND			
	Borehole		
	Dynamic Cone Penetration Test (Cone)		
	Borehole & Cone		
	Auger Probe (AP)		
	Borehole/0.3m (Std. Pen Test, 475 J / blow)		
	Cone/0.3m (Std. Pen Test, 475 J / blow)		
	W.L. of time of investigation September and October 2003		
	Head		
	ARTESIAN WATER		
	Encountered		
	PEZOMETER		

BH No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1001	284.7	5 160 804	281 364
1002	281.3	5 160 807	281 342
1003	282.8	5 160 810	281 353
1004	280.3	5 160 808	281 339
1005	281.2	5 160 811	281 350
1006	281.7	5 160 809	281 346
1007	280.9	5 160 810	281 344
1008	280.3	5 160 814	281 327

(Legend Continues)

The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

Geotechnical No.			
DATE	BY	DESCRIPTION	

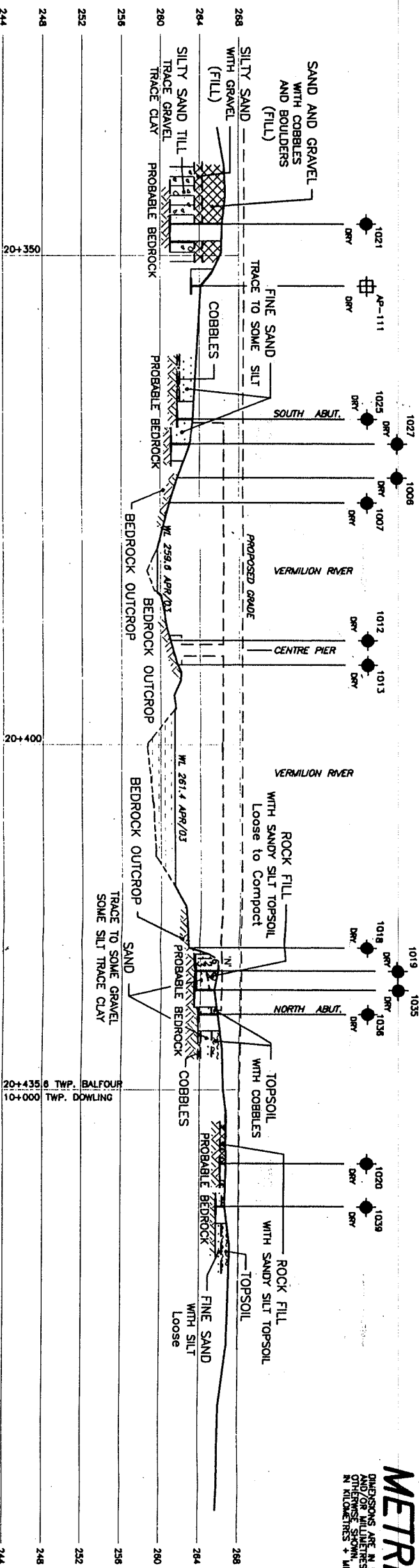
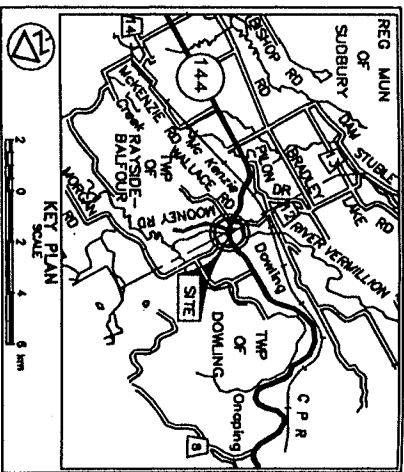
REF No base-vermilion_REV.dwg: February, 2003
00458V01.dwg: October, 2003

NOTE:
REFER TO DRAWING 2 FOR SECTIONS A-A, B-B,
C-C AND D-D.

METRIC
DIMENSIONS ARE IN METRES
UNLESS OTHERWISE SPECIFIED
N = KILOMETRES + METRES

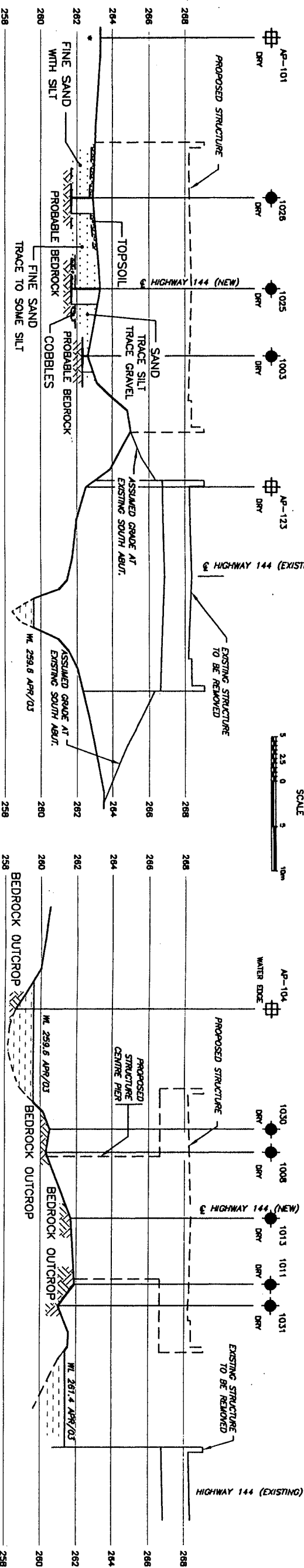
CONT No	
CWP No 158-95-00	
VERMILION RIVER (1my 144, 2.2 km South of Dowling)	
SOIL STRATA	
SHEET	

PMI
Peto MacCallum Ltd
CONSULTING ENGINEERS



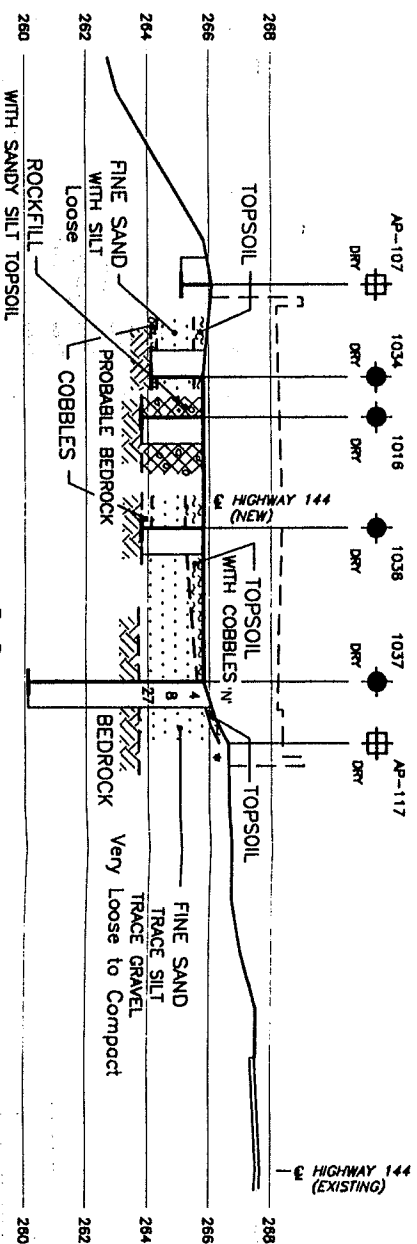
SECTION A-A

SCALE



SECTION B-B

* FROZEN NO PENETRATION



SECTION C-C

SECTION D-D

SECTIONS B-B, C-C AND D-D

- NOTES:
- REFER TO DRAWING 1 FOR PLAN.
 - * DENOTES FROZEN, NO PENETRATION.



REF No E-bose-vermilion_REV.dwg; February, 2003
00458V01.dwg; October 2003

DATE	BY	DESCRIPTION
144	144	144
144	144	144
144	144	144
144	144	144
144	144	144
144	144	144
144	144	144
144	144	144
144	144	144
144	144	144

LEGEND
Borehole
Dynamic Cone Penetration Test (Cone)
Borehole & Cone
Auger Probe (AP)
Borehole/3m (Std. Pen Test, 475 J / blow)
CONE Borehole/3m (Std. Pen Test, 475 J / blow)
W.L. at time of investigation September and October 2003
Head
ARTESIAN WATER
Encountered
PEZLOMETER
CO-ORDINATES
NORTH
EAST

NOTE -
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

APPENDIX A

FACTUAL INFORMATION FROM PRELIMINARY INVESTIGATION REPORT

Table I

Drawing 1

TABLE I

**SITE CONDITIONS AT SURVEY LINES A, B AND C
VERMILION RIVER BRIDGE, HIGHWAY 144, SITE 46-50
2.2 KM SOUTH OF DOWLING, DISTRICT 54, SUDBURY
G.W.P. 158-95-0**

SURVEY LINE A					
AREA ⁽¹⁾	POINT	STATION	OFFSET	ELEVATION ⁽²⁾	COMMENTS
South Abutment	101	20+369.7	30L	263.3	Frozen gravel/ slope
	102	20+380.0	30L	261.6	Rock / Top of bank
	103	20+385.0	30L	259.1	Rock
	104	20+389.0	30L	258.6 (E)	Rock / Edge of water
Centre (Island)	105	20+400.0	30L	PNA	Rock
North Abutment	106	20+420.0	30L	PNA	Sloping rock
	107	20+430.9	30L	266.1	Top of bank / rock deeper than 1 m by probing
	108	10+004.5	30L	266.1	Probed 0.8 m NFP / Possible Rock

SURVEY LINE B					
AREA	POINT	STATION	OFFSET	ELEVATION	COMMENTS
South Abutment	111	20+352.5	15L	264.1	Probed 1 m, Rock deeper than 1 m
	112	20+366.7	15L	PNA	Rock / Top of bank
	113	20+372.5	15L	PNA	Rock
	114	20+375.5	15L	PNA	Rock / Edge of water
North Abutment	115	20+412.5	15L	PNA	Sloping rock
	116	20+418.9	15L	265.2	Top of bank / possible rock fill
	117	20+432.5	15L	266.0	Frozen / flat area

TABLE I

**SITE CONDITIONS AT SURVEY LINES A, B AND C
VERMILION RIVER BRIDGE, HIGHWAY 144, SITE 46-50
2.2 KM SOUTH OF DOWLING, DISTRICT 54, SUDBURY
G.W.P. 158-95-0**

SURVEY LINE C					
AREA	POINT	STATION	OFFSET	ELEVATION	COMMENTS
South Abutment	121	20+347.5	5L	267.6	Frozen gravel / existing road shoulder (behind curb)
	122	20+363.0	5L	263.2	Rock
	122A	20+363.0	5L	263.4	Top of footing
	123	20+368.0	5L	262.5	Rock
	124	20+371.1	5L	PNA	Rock / edge of water
Centre (Island)	125	20+373.5	5L	PNA	Rock / edge of water
	126	20+374.5	5L	261.5	Rock
	127	20+381.6	5L	263.1	Rock
	128	20+387.0	5L	260.7	Rock / edge of water
North Abutment	129	20+400.0	5L	260.7	Rock / edge of water
	130	20+403.0	5L	262.4	Rock

(1) Refer to Drawing 1 for location of Survey Lines.

(2) Ground surface elevation.

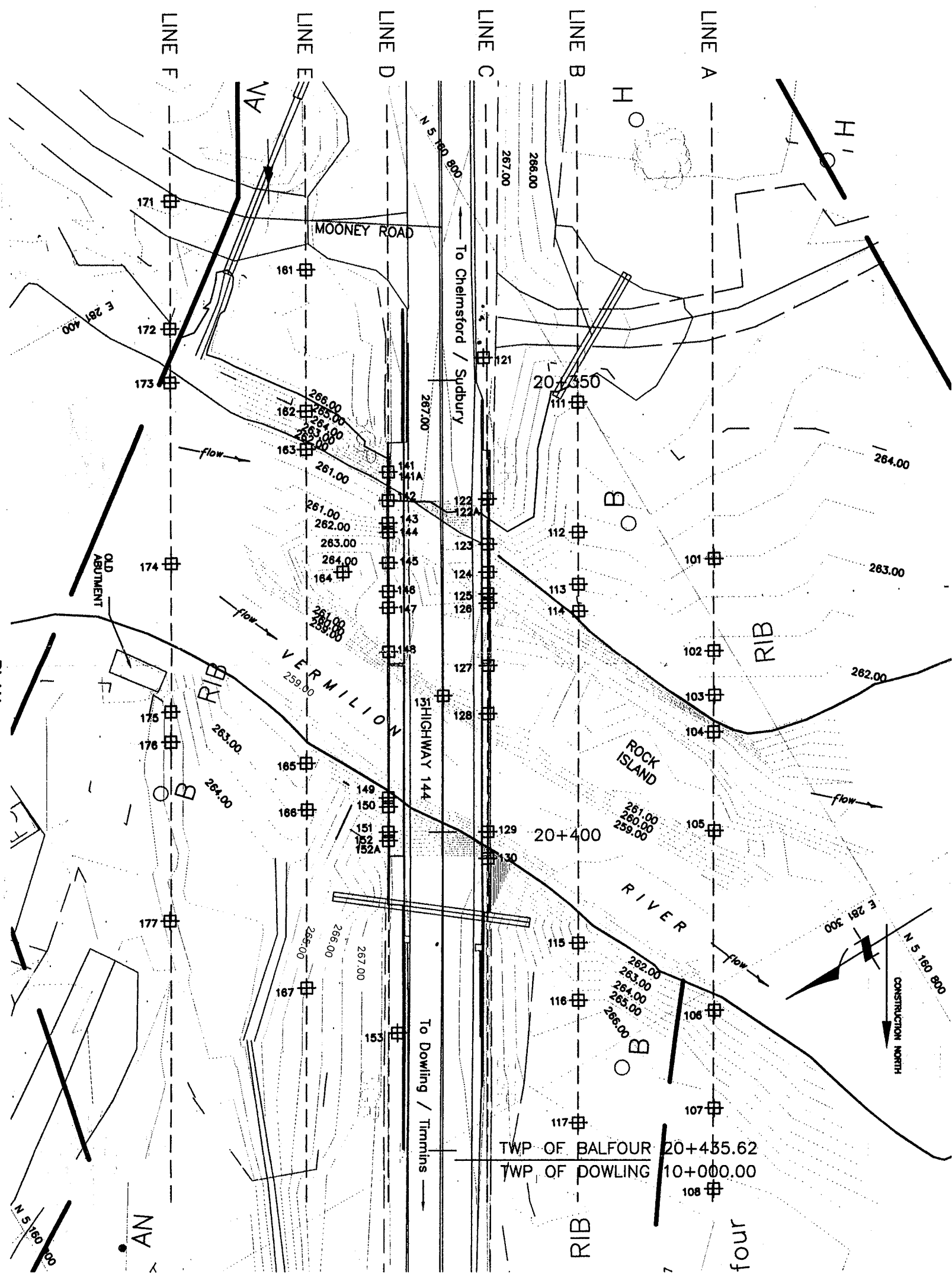
Notes: All stations refer to Township Balfour except Point 108 which is in Township Dowling.
10+000.000 Township Dowling = 20+435.622 Township Balfour.

(E) denotes estimated elevation.

PNA denotes point not accessible.

NFP no further penetration.

Table with 4 columns: AP No, ELEVATION, CO-ORDINATES (NORTH, EAST). Contains data points 111 through 177.



NOTES:
1. POINTS 122A, 141A AND 152A ARE AT TOP OF FOOTING.
2. ELEVATIONS REFER TO SELECTED POINTS AND MAY NOT REFLECT GENERAL TOPOGRAPHY DUE TO JAGGED ROCK SURFACE.

METRIC
DIMENSIONS ARE IN METRES
AND STATIONING IS
CHANGING STATIONS
IN KILOMETRES + METRES

Project information including: CONT No, CWP No 158-95-00, VERMILION RIVER, ALGER PROBE LOCATIONS, and SHEET.

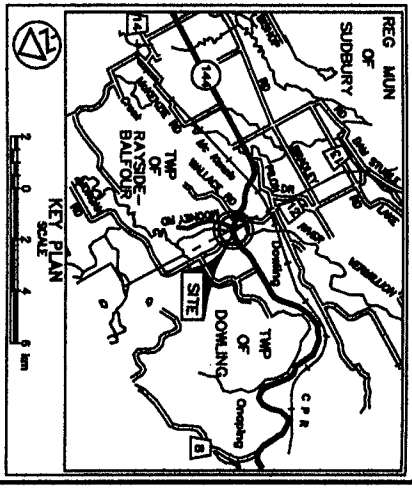


Table with 4 columns: AP No, ELEVATION, CO-ORDINATES (NORTH, EAST). Contains data points 101 through 106.

NOTE: The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

Table with 2 columns: DATE, DESCRIPTION. Includes revision history and dates.

APPENDIX B

Site Photographs – Plates 1 to 14

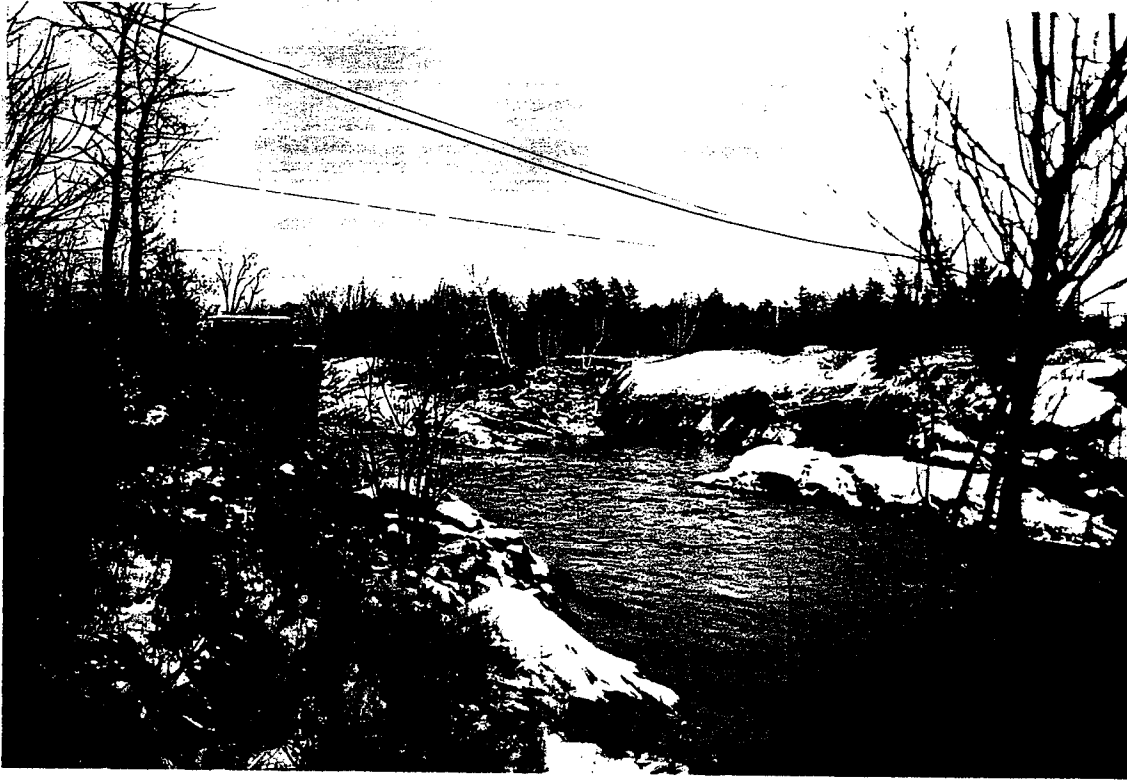


Plate 1: View from east side of north abutment looking south.
Note sloping rock on south side of river.



Plate 2: View from west of bridge looking at north side of river bank.
Note rapids, rock island and north approach area.



Plate 3: View from south bank of river, west of bridge looking east at centre pier.
Note jointing in rock, rapids in channel.



Plate 4: View from north of river, west of bridge looking south.
Note rock island, gradual slope in south bank.

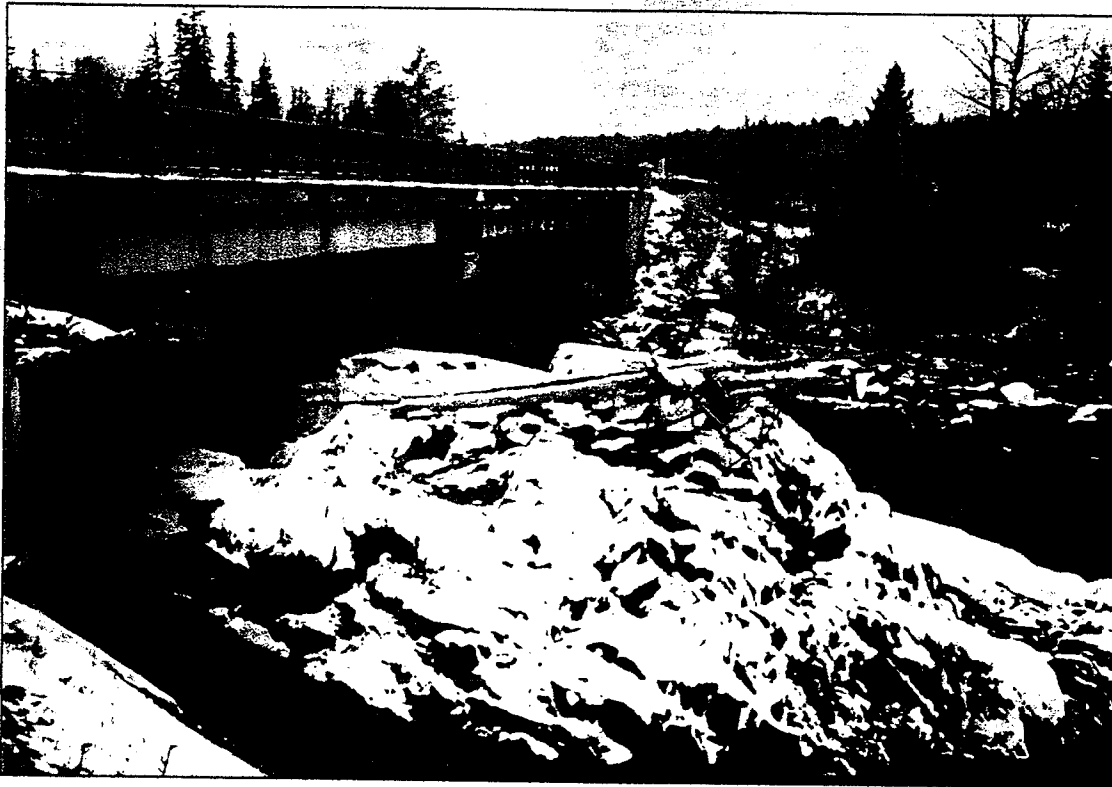


Plate 5: View from south of river east of bridge looking north. Note flat, steeply dipping rock face in foreground, irregular rock surface on island.



Plate 6: Detail of rock below central pier. Note cross joints.

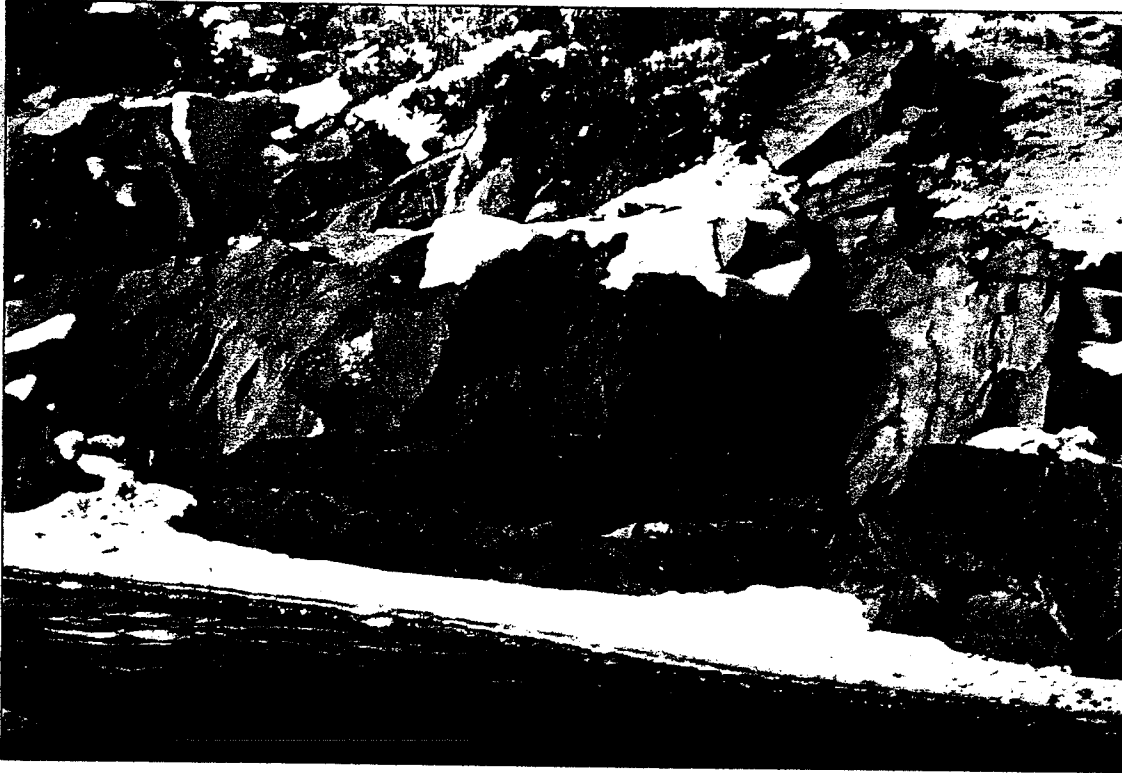


Plate 7: Detail of north side of river in alignment west of existing bridge.
Note overhanging rock.



Plate 8: Detail of rock in front of north abutment.

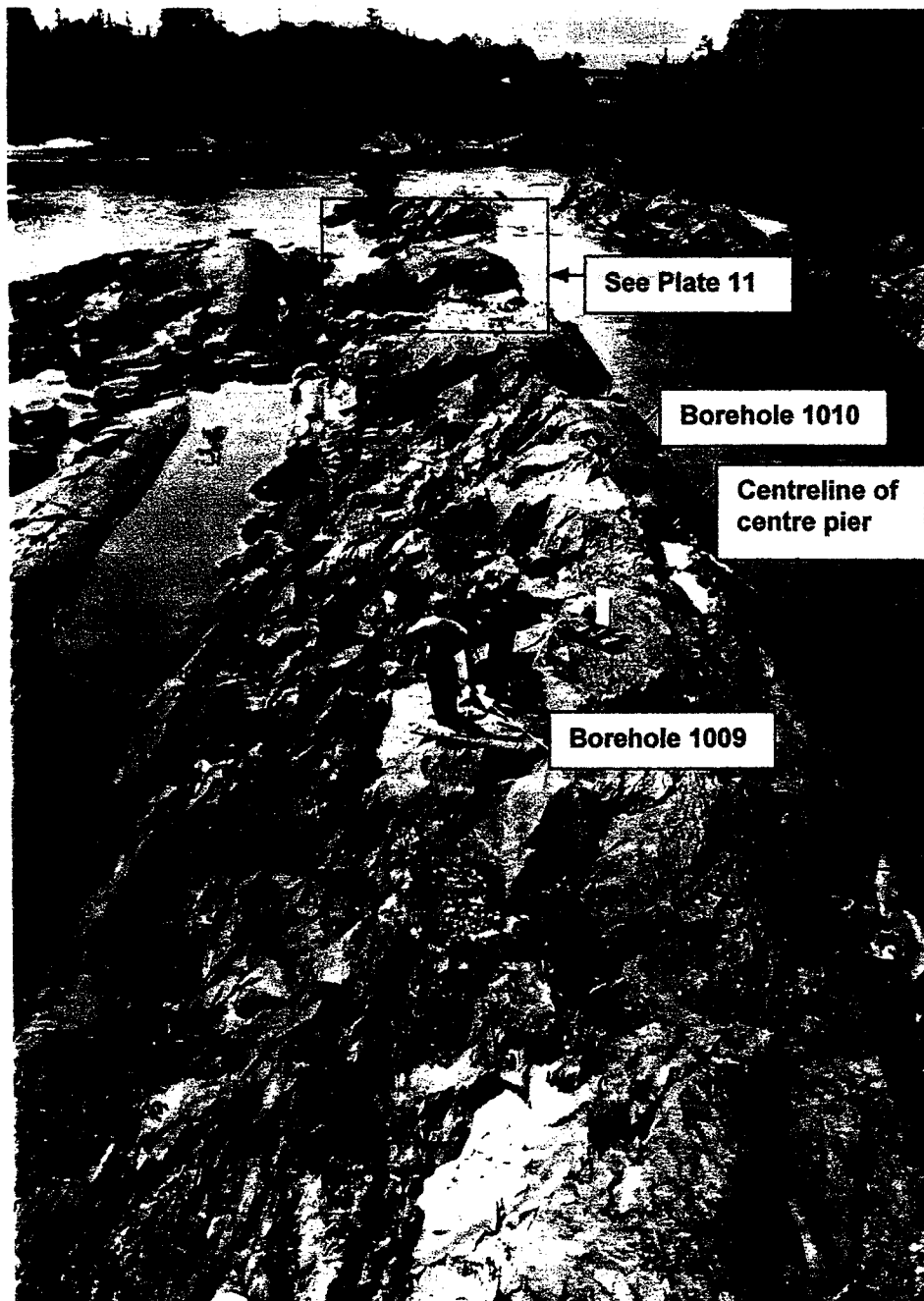


Plate 9: Looking west from existing bridge deck at location of new centre pier. Coring at borehole 1009. Note jagged character of exposed rock surface.



Plate 10: Looking east at new bridge centre pier location. Note jagged character of exposed rock surface.



Plate 11: Looking west at end of rock island showing round features on exposed rock surface.



Plate 12: Close-up of features shown on plate above.

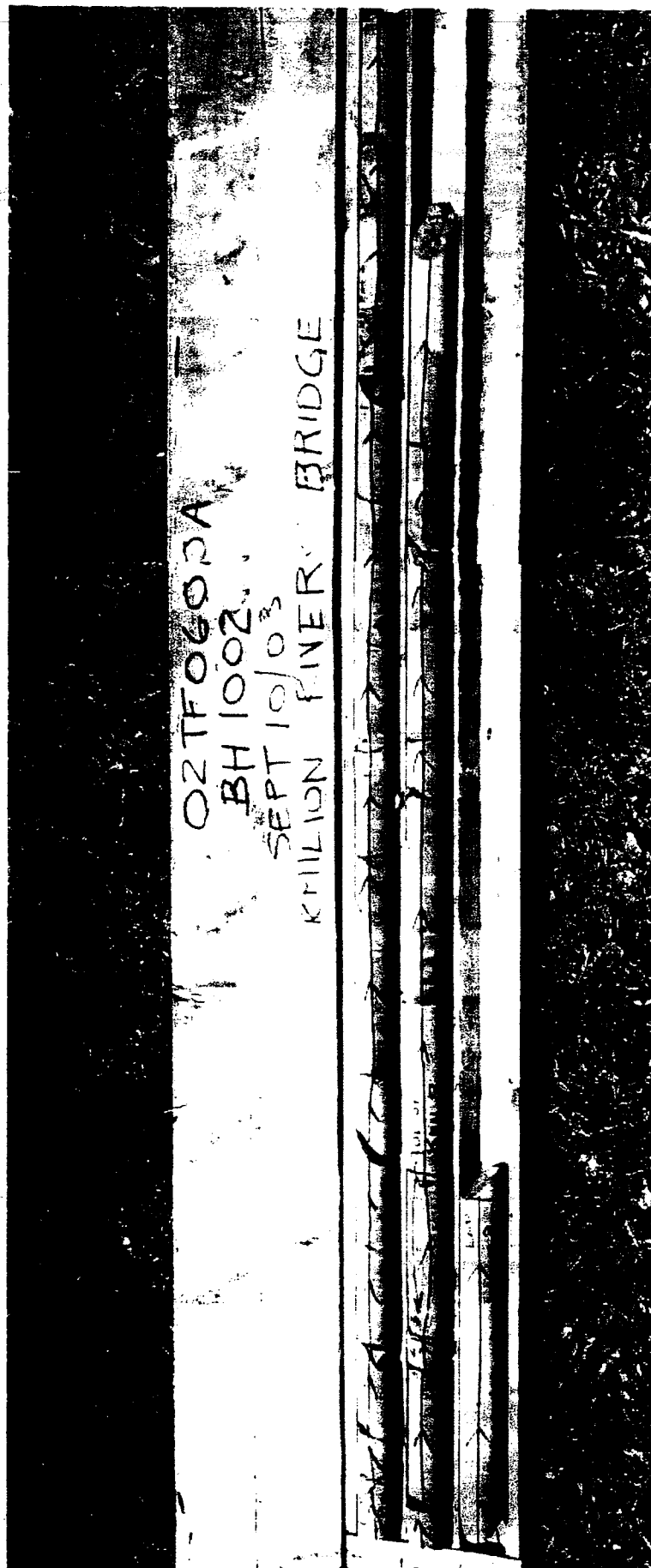


Plate 13: Rock core retrieved from borehole 1002 drilled at south abutment.

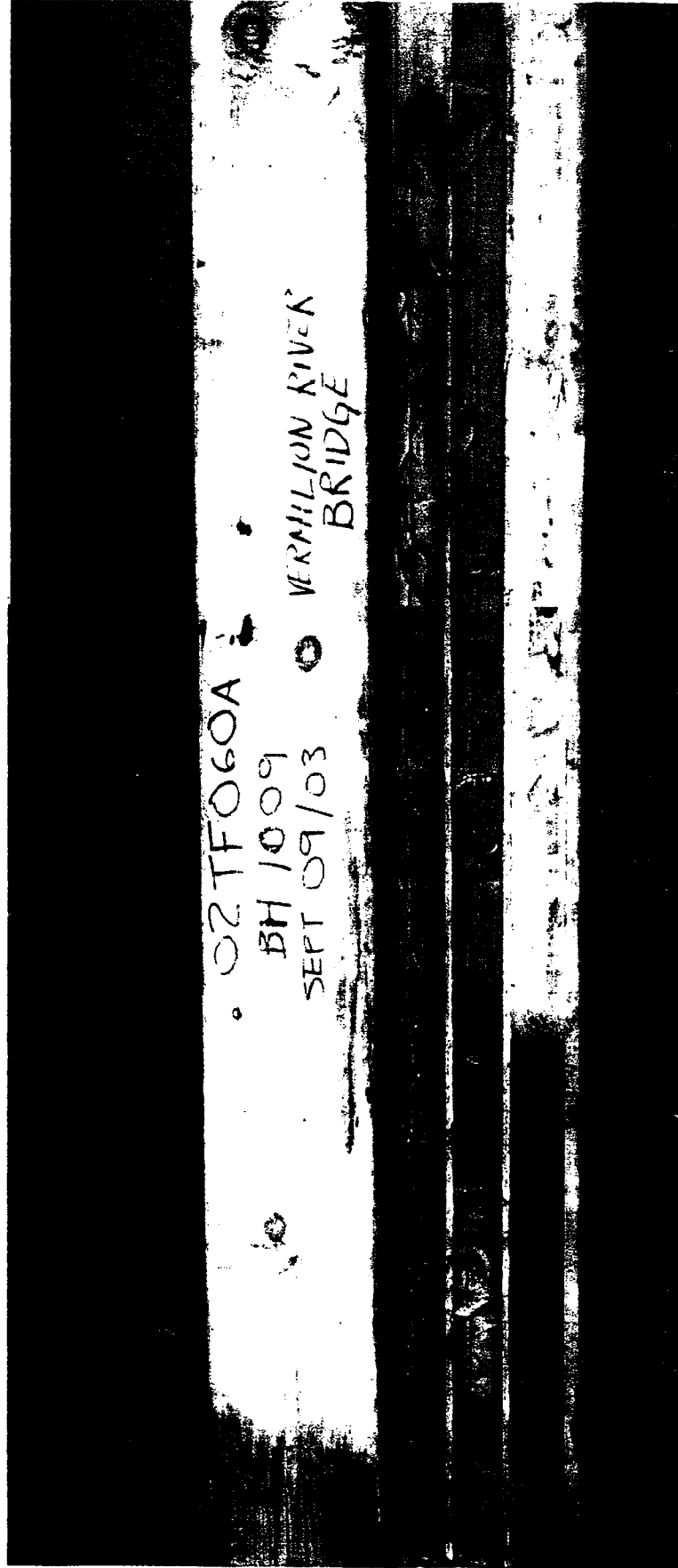


Plate 14: Rock core retrieved from borehole 1009 drilled at centre pier.

**DETAILED FOUNDATION DESIGN REPORT
FOR VERMILION RIVER BRIDGE REPLACEMENT
HIGHWAY 144, SITE 46-50
WP 158-95-00
TOWNSHIPS OF DOWLING AND BALFOUR
DISTRICT 54, SUDBURY**

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LIST OF ENCLOSURE(S):

Sketch: Rock Fill Drainage in Slope Flattened Areas

DETAILED FOUNDATION DESIGN REPORT

for
Vermilion River Bridge Replacement
Highway 144, Site 46-50
WP 158-95-00
Townships of Dowling and Balfour
District 54, Sudbury

INTRODUCTION

This report provides geotechnical comments and recommendations regarding design and construction of foundations, abutments and approaches for the proposed replacement of the Vermilion River Bridge located on Highway 144 west of Sudbury, Ontario. The investigation was conducted for Stantec Consulting Ltd. on behalf of the Ministry of Transportation of Ontario.

Highway 144 passes over the Vermilion River between approximate Station 20+330 (Township of Balfour) and Station 10+005 (Township of Dowling), Highway 144 chainage, about 8 km west of Chelmsford within the Regional Municipality of Sudbury. The present bridge comprises a two span steel plate girder superstructure with a total length of about 40 m. The abutments and centre pier are supported on spread footings founded on bedrock. Road grade on Highway 144 at the bridge location is near elevation 267.5.

Highway 144 is designated as a north-south road. Therefore, the bridge alignment is also considered to be north-south even though the highway is actually oriented in the northwest-southeast direction at the bridge location.

The proposed replacement bridge consists of a 61 m long, 15.3 m wide, two span structure (23.5 and 37.5 m long spans) constructed on a new alignment 15 to 20 m west of the existing structure. The approach embankments to the south and north abutments will be about 2 and 4 m above existing grade, respectively. A retaining wall will also be constructed along the east side of the south abutment (ref. Preliminary General Arrangement Drawing prepared by Stantec

Consulting Ltd. titled "Vermilion River Bridge"; drawing P-2 dated September 2003). During the construction period, the existing bridge will be maintained to transport traffic over the river.

The subsurface stratigraphy revealed in the boreholes drilled at the site generally comprised exposed bedrock or a surficial rockfill and/or sand mantling shallow bedrock. The maximum depth to the bedrock is generally less than 2 m below grade.

FOUNDATIONS

General

The bedrock surface at the test locations is at or within 2 m of existing grade along the alignment of the proposed structure except at the south approach where it is up to 5.3 m below grade. Consequently, it is recommended that the foundation loads of the proposed structure be supported by spread footings constructed on bedrock. It is considered that construction of abutments supported on steel H-piles is not feasible at this site.

The seismic coefficient for the conditions at this site is 1.0 (soil profile Type 1, CHBDC clause 4.4.6).

All footings subject to frost action should be provided with 1.9 m of earth cover or equivalent thermal insulation. A 25 mm thick layer of polystyrene insulation is thermally equivalent to 600 mm of soil cover. Footings bearing directly on bedrock do not require protection from frost.

Construction of the footings should be performed and monitored in accordance with SP 902S01 (December 2001) to verify the competency of the founding surface.

Footings Constructed on Bedrock

The rock mass exhibits a number of intersecting discontinuities that have combined to form a rugged or jagged appearance in some areas, and relatively large flat faces in adjacent areas.

The primary system is very distinct, striking at 58 to 61° and dipping down to the north (true north) at 40 to 50°. It is exposed in the relatively steep rock face that forms the south bank of the river east (upstream) of the existing bridge. This system controls the structure of the rock and, as a consequence, the alignment of the river channel at the site. Joint spacing ranges from about 200 mm up to 1 m and may be classified as close to moderate. The joints are generally tight or locally oxidized. The face is typically smooth planar.

Secondary cross jointing is evident, although more poorly defined than the primary system. It is typically almost perpendicular to the main system. Spacing is close to moderate. Joints are tight to oxidized and the face is typically smooth planar.

There is also evidence of an additional more poorly defined system(s) that cuts across the first two at varying angles.

The bedrock surface elevation along the alignment of the abutments and centre pier is reasonably consistent as illustrated in the following table:

Foundation Unit	BEDROCK SURFACE ELEVATION		
	Overall Range (m)	Longitudinal Variation at Adjacent Test Locations (m)	Lateral Variation at Adjacent Test Locations (m)
South Abutment and Retaining Wall	Typically 260.7 to 262.4; 265.0 and 264.4 at boreholes 1040 and 1041 respectively	Less than 1 m	0.5 to 1.0 m, except in north half of retaining walls (2.0 m)
Centre Pier	260.1 to 261.9	Less than 0.5 m	0 to 0.8 m; 1.8 m at boreholes 1009 and 1011
North Abutment	Typically 263.4 to 264.1; 260.9 in southwest part of footing and up to 266.1 in the northwest and northeast part of the wingwalls	Less than 0.7 m, except in northeast and southwest parts of footing where the variation is 2.5 and 3.2 m respectively	Less than 0.5 m, except in north and southwest parts of footing where the variation is up to 2.6 and 3.2 m respectively

Cognizant of the complex structure of the bedrock at this site and the relatively thin jointing and/or foliation planes, it is recommended that the footings are founded at or above the rock surface at the elevations indicated in the following table to avoid the need for blasting:

Foundation Unit	Ideal Founding Elevation
South Abutment	262.7
South Abutment Retaining Wall	265.5
Centre Pier	262.0
North Abutment	264.3

Further, the outside edge of the abutment footings should be set back at least 1.5 m from a line inclined upwards at 1 horizontal:2 vertical (1H:2V) from the toe of the rock slope adjacent to the creek. The 1.5 m setback is recommended to account for the geologic structure of the bedrock.

If footings are founded within 1.5 m from a line inclined upwards at 1H:2V, it will be necessary to reinforce the rock mass with tensioned rock bolts (SP 999S26 December 2002). The rock bolts should be 2.5 m long (based on 1 m thick joint spacing and 1.5 m anchor zone) and spaced at intervals of 1.5 m (longitudinal) along the length of the footing.

Footings bearing on the sound bedrock should be designed using a factored bearing resistance at ULS of 10,000 kPa. Considering the bedrock to be non-yielding, the design will not be governed by settlement criteria since the loading required to produce 25 mm deformation is much larger than the factored capacity at ULS. The bearing resistance for inclined loads should be reduced in accordance with the requirements of clause 6.7.4 of the Canadian Highway Bridge Design Code (CHBDC), (CAN/CSA-S6-00).

Mass concrete could be placed to provide a level founding surface for the footings and/or be employed to raise the subgrade to the design founding level of the footings. The need to expand the plan area at the base of the mass concrete to provide for stress distribution (2V:1H), place reinforcing steel in the mass concrete and/or use high strength concrete to prevent overstressing of the mass concrete will be dictated by the actual thickness of the mass concrete and structural design considerations.

Subject to these comments, the bearing resistance provided for footings bearing on bedrock is considered to be appropriate for mass concrete with an unconfined compressive strength of at least 35 MPa.

Comments concerning excavation of the bedrock, if required to found the footings at a lower level than indicated in the previous table, are provided in subsequent sections of the report.

The horizontal force imposed on the foundations will be resisted in part by the friction force developed between the underside of the footing and the bedrock. An unfactored friction factor of 0.7 is considered to be suitable at this site due to the "rough bedrock surface" (asperity height of at least 25 mm).

The lateral resistance of footings founded on bedrock could be increased by installing anchors into the bedrock (SP 999S26, December 2002). The increased lateral resistance will be provided by the shear strength of the steel dowels, the horizontal resistance of the bedrock, the horizontal component of tensile forces developed in any inclined anchors and/or a greater frictional resistance between the footing and rock if the anchors are prestressed to increase the vertical pressure. The factored horizontal resistance at ULS of the bedrock is considered to be 5000 kPa.

A factored bond stress at the rock/grout interface of 1.4 MPa at ULS (a resistance factor of 0.4 is applied for a minimum 35 MPa grout) is recommended for design. The anchors should extend a minimum 30 bar diameters into sound bedrock and be spaced at a distance of at least four times the diameter of the anchor hole. The total capacity of a group of closely spaced anchors may be less than the summed capacities of the individual anchors; the impact of anchor interaction should be assessed if the spacing is less than one-fifth of the anchor length. Anchor testing should be conducted in accordance with clause 6.10.4 (CHBDC).

RETAINING AND ABUTMENT WALLS

The retaining and abutment walls should be designed to resist the unbalanced lateral earth pressure imposed by the backfill adjacent to the wall above the bedrock surface (assuming the horizontal clearance between the vertical cut face of the rock and the abutment is more than 1 m) or the compaction pressure imposed during placement of the backfill. The lateral earth pressure, p (kPa), may be computed using the equivalent fluid pressure diagrams presented in Section 6.9 of the CHBDC or employing the following equation, assuming a triangular pressure distribution.

$$p = K(\gamma h + q) + C_p$$

where K = coefficient of lateral earth pressure (dimensionless)

γ = unit weight of free-draining granular material (kN/m³)

h = depth below final grade (m)

q = surcharge load (kPa) if present.

C_p = compaction pressure (refer to clause 6.9.3 of CHBDC)

Free-draining granular material or rockfill should be used as backfill behind the wall. The following parameters are recommended for design:

	<u>Granular "A"</u>	<u>Granular "B"</u>	<u>Rockfill</u>
Angle of Internal Friction, degrees	35	32	42
Unit weight, kN/m ³	22.8	21.2	18.0
Coefficient of Active Earth Pressure K_a	0.27	0.31	0.20
Coefficient of Earth Pressure At Rest K_o	0.43	0.47	0.33
Coefficient Passive Earth Pressure K_p	3.69	3.25	5.04

The coefficient of earth pressure at rest should be used for design of rigid and unyielding walls, the active earth pressure coefficient for unrestrained structures.

A weeping tile system and/or weep holes should be installed to minimize the build-up of hydrostatic pressure behind the wall. The weeping tiles should be surrounded by a properly designed granular filter or geotextile to prevent migration of fines into the system. The drainage pipe should be placed on a positive grade and lead to a frost-free outlet.

It appears that a retained soil system will not be suitable at this site since the approach embankments will be less than 4 m high.

APPROACH EMBANKMENTS

Backfilling adjacent to the structure should be carried out in conformance with Ontario Provincial Standards Specifications for granular rock backfill at abutments (OPSD 3501.00 and 3505.00).

It is anticipated that the approach embankments will be about 2 m (south) and 4 m (north) high and constructed with earth borrow/granular materials. The field investigation indicates the approach fill will generally be founded on exposed bedrock or a thin soil cover underlain by shallow bedrock. Construction of the embankment fill on the bedrock and/or native soil deposits is considered to be feasible.

The embankments should be constructed in accordance with OPSD 201.010, 201.020, 202.010, 208.010 and OPSS 206 dated December 1993, amended by Special Provision dated June 20, 2001 (draft). The side slopes of approach embankments should be inclined no steeper than 2 horizontal to 1 vertical for earth fill and 1.25 horizontal to 1 vertical for rockfill. Since the height of fill is expected to be less than 6 m, a mid-height berm will not be required.

Where slope flattening is proposed, a drainage gap should be provided in accordance with OPSD 202.020. Where slopes are flattened to eliminate the need for a guide rail, a granular infilled drainage gap should be provided in accordance with the Northeastern Region Pavement Design Practices and Guidelines as shown in the appended sketch "Rockfill Drainage in Slope Flattened Areas". OPSS Granular "B" Type II should be used for the drainage gap.

The embankment will be constructed on bedrock overlain by a relatively thin soil layer; the platform width should be widened by 1 m in accordance with the Northeastern Region Engineering Directive (NRE 98-200) dated October 28, 1998.

It is considered that the approach embankments constructed in accordance with these recommendations will be stable. Settlement of the embankment fill due to consolidation of the underlying bedrock will be negligible.

Settlement of the road surface during and following completion of construction will result from two mechanisms – consolidation of the soil below the embankment fill and “self weight” consolidation of the embankment fill.

The magnitude of “consolidation” of the embankment fill will be a function of the workmanship employed by the contractor and if placed in 200 to 300 mm thick lifts compacted to 98% of standard density, in accordance with the requirements of SP902S01 amended December 2001 and OPSS501 dated February 1996 (Method A), should be in the order of 5 to 10 mm.

Consolidation of the underlying soil where present, is also expected to be in the order of 5 to 10 mm. Hence, the total consolidation settlement could be 10 to 20 mm. The settlement is expected to be essentially complete within two to four months following placement of the fill.

EXCAVATION AND GROUNDWATER CONTROL

Excavation for construction of footings founded on bedrock will extend through a thin soil cover and/or rockfill of the existing approach embankments.

These materials are classified as a Type 3 soil according to Occupational Health and Safety Act (Ontario Regulation 213/91) criteria. Therefore, temporary cut slopes inclined at 45° to the horizontal should be stable. Flatter sideslopes may be required if excessively soft/wet materials or concentrated seepage zones are encountered locally.

A large excavator equipped with a tiger-toothed bucket in conjunction with a jackhammer or hoe ram is the preferred method of excavation to shallow depths in rock. Conventional rock excavation techniques such as blasting (OPSS 120 "General Specification for the Use of Explosives" dated August 1994) may also be required. The actual equipment required and method of excavation within the bedrock will be dependent upon the geometry of cut and relative depth of excavation into the bedrock. Mass concrete could be employed to level minor variations in the bedrock surface.

It is important that blasting of the rock is controlled to prevent fracturing and/or disturbance of the bedrock surface on which footings will be founded. This is particularly important at this site due to the complex geologic structure of the bedrock. Any overblasting/overexcavation should be made the sole responsibility of the contractor and all loosened rock resulting from blasting operations is to be removed by mechanical means.

Near vertical sidewalls may be utilised in excavations in bedrock. Examination of the sidewalls and removal of any loosened rock fragments should be carried out continually for the safety of workmen.

There was no evidence of groundwater in any of the boreholes or water seepage along the banks of the river in the exposed areas. However, minor seepage should be anticipated locally at the soil/bedrock interface, at the depressions in the bedrock surface, and in association with discontinuities in the bedrock close to or below the level of the adjacent river. Groundwater levels are subject to seasonal fluctuations and precipitation patterns.

It is anticipated that conventional sump pumping techniques will be sufficient to control seepage of groundwater into the excavations.

Construction should be scheduled during the drier time of the year (typically June to September) to minimize the potential for "flood" conditions during construction.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with local/MTO regulations.

DETOUR CONSIDERATION

Current plans call for the existing bridge to be maintained while the replacement structure is constructed. Consequently, construction of a detour structure will not be necessary.

CLOSURE

The report was prepared by Mr. G.O. Degil, Ph.D., P.Eng., Senior Foundation Engineer. It was reviewed by Mr. D.W. Kerr, M.Eng., P.Eng., Chief Foundation Engineer. Mr. B.R. Gray, M.Eng., P.Eng., carried out an independent review of the report.

Yours very truly

Peto MacCallum Ltd.



A handwritten signature in black ink, appearing to read "D. W. Kerr", written over a horizontal line.

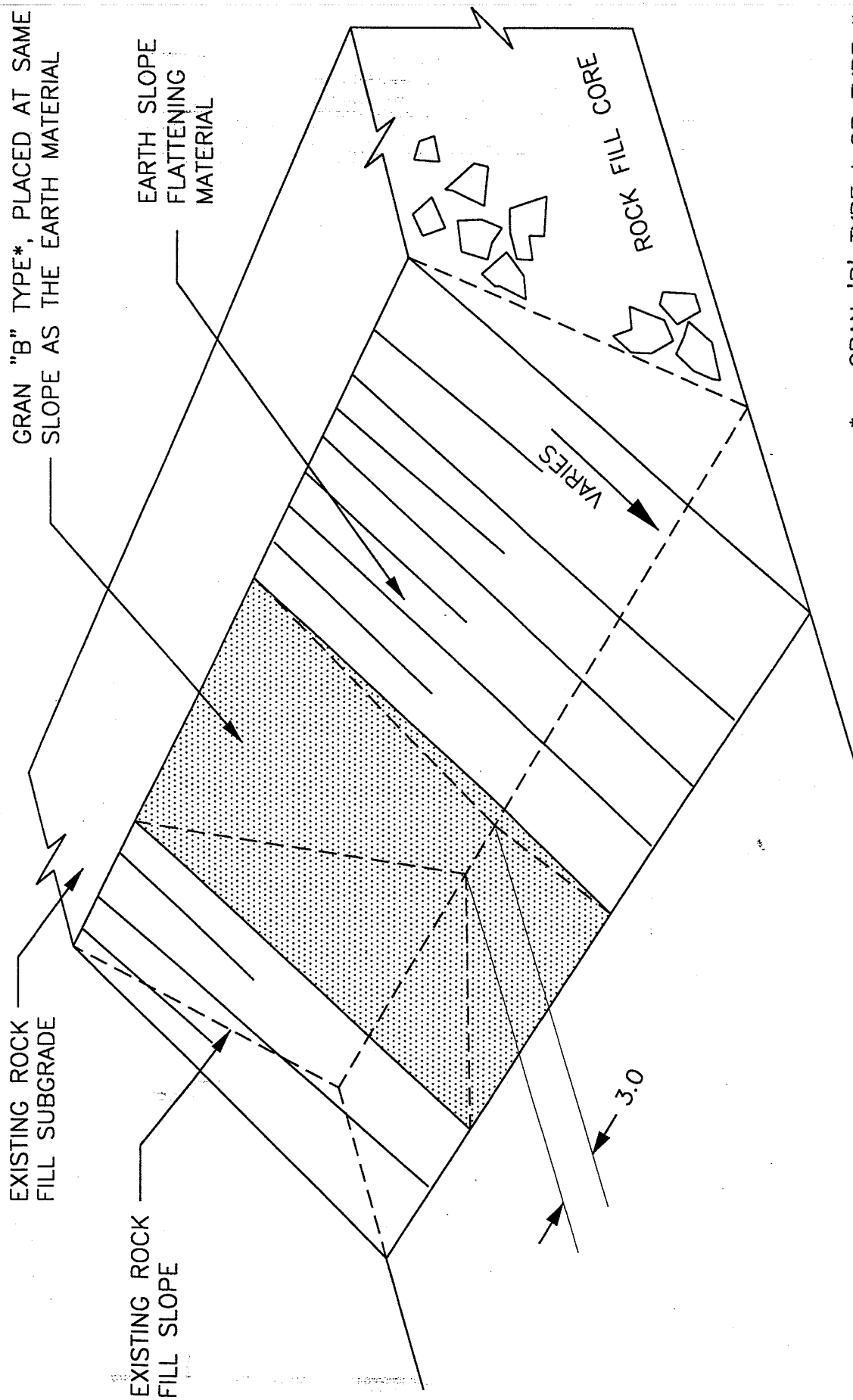
Dennis W. Kerr, M.Eng., P.Eng.
Chief Foundation Engineer



A handwritten signature in black ink, appearing to read "Brian R. Gray", written over a horizontal line.

Brian R. Gray, M.Eng., P.Eng.
MTO Designated Contact

GD:mi:lad



* GRAN 'B' TYPE I OR TYPE II AS RECOMMENDED FOR PROJECT.

ROCK FILL DRAINAGE IN SLOPE FLATTENED AREAS

NOT TO SCALE